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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04Q 7/38 | A2

(11) International Publication Number: **WO 00/24216**

(43) International Publication Date: 27 April 2000 (27.04.00)

(21) International Application Number: PCT/SE99/01766

(22) International Filing Date: 5 October 1999 (05.10.99)

(30) Priority Data:
09/177,457 22 October 1998 (22.10.98) US

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

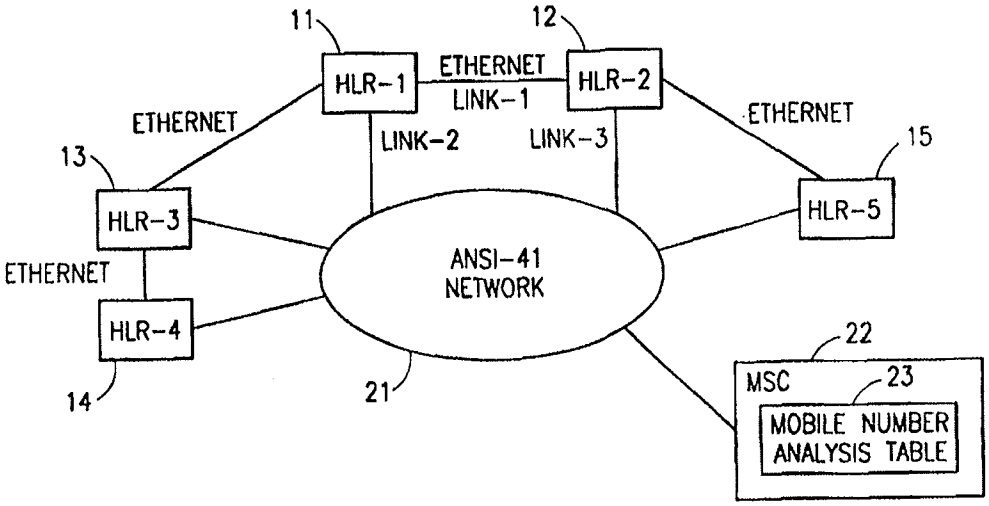
(72) Inventor: FOTI, George; 2967 Lake Road, Dollard des Ormeaux, Quebec, H9B 2MI (CA).

(74) Agent: ERICSSON RADIO SYSTEMS AB; Common Patent Dept., S-164 80 Stockholm (SE).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: DYNAMIC HLR REDUNDANCY IN A RADIO TELECOMMUNICATIONS NETWORK



(57) Abstract

A system and method of providing dynamic redundancy of home location registers (HLRs) for a plurality of subscribers in a radio telecommunications network having a plurality of HLRs (11–15), each of which has excess memory capacity for storing subscriber records. Each of the HLRs in the network operates as both a primary HLR and a secondary HLR. Subscriber records (10) in each HLR are divided into a plurality of subsets of known size. For each subset of records in a particular HLR, another HLR in the network is designated as the secondary HLR. The primary HLR (11) and the secondary HLR (12) for each subscriber are identified to the network through new subscriber categories. A heartbeat signal is periodically sent back and forth between the primary HLR and the secondary HLR in each HLR pair to convey the operational status of each HLR in the pair. If the heartbeat signal is not received in a secondary HLR, the secondary HLR sends to the network a Qualification Directive (QUALDIR) Invoke message directing the network (21) to utilize the secondary HLR sending the message as the new primary HLR for the assigned subset. The secondary HLR records all changes made to its subscriber records until the primary HLR is operational, and the heartbeat signal is resumed. The secondary HLR then updates the primary HLR, and the primary HLR is redesignated as the primary HLR.

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DYNAMIC HLR REDUNDANCY IN A RADIO TELECOMMUNICATIONS NETWORK

BACKGROUND OF THE INVENTION

Technical Field of the Invention

This invention relates to telecommunication systems and, more particularly, to a system and method of providing redundancy of home location registers (HLRs) in a radio telecommunications network.

Description of Related Art

In existing radio telecommunications networks, HLR redundancy is provided on a 1-to-1 basis. In other words, if a primary HLRs fails, the backup HLR is completely utilized to restore the service of the failed HLR. Some systems utilize a configuration known as hot standby in which a backup HLR is implemented for each primary HLR in the network in order to have a backup for all subscriber records at all times. Thus, if there are five primary HLRs in the network, then five backup HLRs are required. This is a very expensive and wasteful system architecture. To avoid this expense, other networks utilize a configuration known as cold standby in which a single HLR is implemented to backup a plurality of primary HLRs. However, if one of the primary HLRs fails, the backup HLR is completely utilized to restore the service of the failed HLR. The other primary HLRs are then without a backup until repairs to the failed primary HLR can be made.

The process of switching to a backup HLR is also inefficient and time consuming. Presently, the network determines that the primary HLR has failed when a mobile switching center (MSC) attempts to access the primary HLR and the attempt times out and fails. The timeout takes several seconds and may cause some calls to fail or be prematurely abandoned because of the delay in connecting the call. In addition, when the primary HLR is restored, its data must be reloaded. This is performed by loading the data from a backup copy on a tape or disk. The restoration process takes additional time while this physical medium transfers the data. Additionally, although the backup tape or disk may be the most recent available, it is

not completely up to date. Therefore, inaccuracies in the subscriber records result after the primary HLR is restored.

There are no known prior art teachings of a solution to the aforementioned deficiency and shortcoming such as that disclosed herein. In order to overcome the disadvantage of existing solutions, it would be advantageous to have a system and method of dynamic HLR redundancy in radio telecommunications networks that has a faster switchover time, makes more efficient use of system resources, and is less expensive to implement. The present invention provides such a system and method.

SUMMARY OF THE INVENTION

In one aspect, the present invention is a system for providing dynamic redundancy of home location registers (HLRs) for a plurality of subscribers in a radio telecommunications network. The present invention divides the subscriber records in each HLR into a plurality of subsets. Then, rather than allocating an entire backup HLR to backup one or more primary HLRs, the present invention allocates each subset to a different HLR that acts as a secondary HLR for that subset. Thus, each of the HLRs in the network operates as a primary HLR for some subsets of data, and as a secondary HLR for other subsets.

In another aspect, the present invention is a system for providing dynamic redundancy of HLRs which includes a primary HLR and a plurality of secondary HLRs, each of which has excess memory capacity for storing subscriber records. The primary HLR stores a set of subscriber records which are divided into a plurality of subsets of known size. The system also includes means for determining the amount of excess memory capacity in each of the plurality of secondary HLRs, and means for assigning, as a backup for each of the subsets of subscriber records, a different one of the plurality of secondary HLRs with sufficient excess memory capacity to store the assigned subset of subscriber records.

In another aspect, the present invention is a method of providing dynamic redundancy of HLRs in a radio telecommunications network having a plurality of HLRs. Each of the HLRs has excess memory capacity for storing subscriber records. The method includes the steps of dividing the set of subscriber records in each HLR

into a plurality of subsets. For a given subset of subscriber records, one of the HLRs is designated as its primary HLR, and one of the other HLRs in the network is assigned as a backup secondary HLR for the subset. For each of the subsets, a different one of the plurality of secondary HLRs may be assigned. Alternatively, the system operator may choose not to back up selected subsets, or to back up more than one subset in a particular secondary HLR. The assigning step includes determining the amount of excess memory capacity in each of the plurality of secondary HLRs, determining the size of each subset of subscriber records, and assigning as a backup for each of the subsets, a secondary HLR with sufficient excess memory capacity to store the assigned subset of subscriber records.

In yet another aspect, the present invention is a method of providing dynamic redundancy of HLRs for a plurality of subscribers in a radio telecommunications network which includes the steps of assigning a primary and secondary HLR for each subscriber, identifying to the network the primary HLR and the secondary HLR for each subscriber through new subscriber categories, and providing a signaling connection between the primary HLR for each subscriber and the secondary HLR for each subscriber. Records are kept identical in both the primary HLR and the secondary HLR. This is accomplished by periodically sending a heartbeat signal back and forth between the primary HLR and each secondary HLR indicating the operational status of each HLR to the other HLR in the pair. If the heartbeat signal is not received in a secondary HLR for an assigned subscriber, and the subscriber is active, a first directive message is sent from the secondary HLR to the network directing the network to utilize the secondary HLR sending the message as the new primary HLR for the assigned subscriber. The secondary HLR then records all changes made to the subscriber's record in the secondary HLR after sending the first directive message. If the heartbeat signal is again received in the secondary HLR, all the recorded changes made to the subscriber's record in the secondary HLR are sent to the original primary HLR. The secondary HLR then sends a second directive message to the network directing the network to once again utilize the original primary HLR as the new primary HLR for the subscriber.

If the subscriber's secondary HLR fails, the heartbeat signal is not received in

the subscriber's primary HLR. The primary HLR then stops sending the heartbeat signal and records all changes to the subscriber's record until the heartbeat signal is again received. At that time, the primary HLR resumes sending the heartbeat signal and sends all the recorded changes to the subscriber's record to the newly restored secondary HLR.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and its numerous objects and advantages will become more apparent to those skilled in the art by reference to the following drawings, in conjunction with the accompanying specification, in which:

FIG. 1 is a simplified block diagram illustrating the present invention's allocation of backup memory space in a network having a plurality of home location registers (HLRs); and

FIG. 2 is a simplified block diagram of a radio telecommunications network with backup HLRs implemented in accordance with the teachings of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

FIG. 1 is a simplified block diagram illustrating the present invention's allocation of backup memory space in a network having a plurality of home location registers (HLRs) 11-13. The present invention divides the subscriber records in each HLR into a plurality of subsets. Then, rather than allocating a backup secondary HLR to back up each primary HLR (hot standby), or allocating a backup secondary HLR to back up a plurality of primary HLRs (cold standby), the present invention allocates each subset to a different HLR that acts as a secondary HLR for that subset. Thus, each of the HLRs in the network operates as both a primary HLR for some subsets of data, and as a secondary HLR for other subsets. Although three HLRs are depicted in FIG. 1, and the subscriber records are shown divided into four subsets, it should be understood that a greater or lesser number of HLRs, and a greater or lesser number of subsets may be utilized to implement the present invention.

As shown in FIG. 1, HLR-1, HLR-2, and HLR-3 11-13 each have subscriber records 10 divided into four subsets. For illustrative purposes, each HLR operates as

a primary HLR for two subsets of records, and as a secondary HLR for two subsets of records. In HLR-1, for example, a first subset of records utilizes HLR-1 as the primary HLR (Pri = HLR-1) and HLR-2 as the secondary HLR (Sec = HLR-2). A second subset of records utilizes HLR-1 as the primary HLR (Pri = HLR-1) and HLR-3 as the secondary HLR (Sec = HLR-3). Relationship links from these subsets to HLR-2 and HLR-3 illustrate the backup relationship of HLR-2 and HLR-3 and illustrate that a portion of the memory space in HLR-2 and HLR-3 is allocated to backup these records.

HLR-1 also includes a third subset of records which are backup records for a subset for which HLR-2 is the primary HLR. HLR-1 also includes a fourth subset of records which are backup records for a subset for which HLR-3 is the primary HLR. This illustrates that HLR-1 operates as both a primary HLR for two subsets of records, and as a secondary HLR for two subsets of records. FIG. 1 also illustrates that if HLR-1 fails, several HLRs (i.e., HLR-2 and HLR-3) will back up portions of the records stored in HLR-1. Also, subscriber records from several HLRs are backed up by HLR-1. For example, if both HLR-2 and HLR-3 fail, a portion of their records are backed up in HLR-1.

Thus, the present invention allows selected subsets of subscriber information from each HLR to be backed up in selected HLRs which operate as secondary HLRs for those subsets. The subsets may consist of selected types of information for each subscriber. The subsets may also be complete records of selected subscribers such as priority subscribers, or some combination of selected information and selected subscribers. The subsets may be defined in such a way as to most efficiently fit within the spare capacity available for backup in the secondary HLRs. Alternatively, the system operator may choose not to back up selected subsets, or to back up more than one subset in a particular secondary HLR.

FIG. 2 is a simplified block diagram of an ANSI-41 radio telecommunications network 21 with a plurality of HLRs implemented in accordance with the teachings of the present invention. As noted above, a plurality of HLRs may be connected on the network, and any HLR can back up one or more subsets of records from any other HLR, or subsets from several other HLRs. For each subscriber, however, only one

HLR is assigned as the subscriber's primary HLR, and one HLR is assigned as the subscriber's secondary HLR. In the illustrated case discussed below, HLR-1 is the primary HLR for a particular subscriber, and HLR-2 is the backup or secondary HLR.

Two new categories are created in the subscriber profile to record the subscriber's primary and secondary HLRs. In addition, the MSC 22 maintains in a mobile number analysis table 23, the identity of the primary HLR and the secondary HLR for each number series or subscriber. For illustrative purposes, only the links and interactions between HLR-1 and HLR-2 are described below. It should be understood, however, that for different subscribers, similar links and interactions also take place between each primary and secondary HLR pair in the network.

The primary HLR-1 and the secondary HLR-2 are connected via Link-1 which may be, for example, part of an Ethernet network or a wide band network linking the HLRs. Changes made to subscriber records in the primary HLR-1 are propagated over Link-1 to HLR-2 where duplicate entries are made. Thus, HLR-2 always has up-to-date backup subscriber records. It is critical that each HLR in this HLR pair know the operational status of the other HLR in the pair at all times in order to properly update assigned records in each HLR. For this purpose, a heartbeat signal is propagated over Link-1 back and forth between the primary HLR-1 and the secondary HLR-2 to inform each HLR of the operational status of the other HLR in the pair. This signal may be sent, for example, once each second. Thus, HLR-2 knows within a second whether or not HLR-1 is operational.

Under certain conditions, such as the failure of the primary HLR-1 or the failure of Link-1, the secondary HLR-2 no longer receives the heartbeat signal. At that time, HLR-2 takes over as the primary HLR for those subscribers for whom HLR-2 is designated as the secondary HLR. The subscriber categories for those subscribers are changed to indicate that HLR-2 is the new primary HLR. HLR-2 then sends a Qualification Directive (QUALDIR) Invoke message to the MSC 22 informing the MSC that HLR-2 is now the primary HLR for those subscriber records for which the subscriber is active, and HLR-2 is the designated backup HLR. The QUALDIR message is sent to the MSC in which the subscriber is currently operating. This procedure is much faster than the prior art method of waiting for an access attempt to

the primary HLR to time out and fail before the network accesses the secondary HLR.

If the subscriber's secondary HLR fails, the heartbeat signal is not received in the subscriber's primary HLR. The primary HLR then stops sending the heartbeat signal and records all changes to the subscriber's record until the heartbeat signal is again received. At that time, the primary HLR resumes sending the heartbeat signal and sends all the recorded changes to the subscriber's record to the newly restored secondary HLR.

Each HLR has to know (1) which HLR it is paired with for each subscriber record, (2) whether it is the primary or secondary HLR for that record, and (3) the current status of the other HLR in the pair. Whichever HLR is currently serving as the primary HLR in a HLR pair is responsible for updating the subscriber records in the secondary HLR. Therefore, when one of the HLRs in the pair goes down, the other HLR saves all changes made to subscriber records designated for the failed HLR until the failed HLR is restored. When the failed HLR is restored, it is then updated with the interim changes, and the original primary-secondary relationship is restored.

Table 1 below illustrates the actions taken by the present invention in various cases in which either HLR-1, Link-1, Link-2, or some combination of the above are inoperative. Note that when a HLR is referred to as a primary or secondary HLR, this designation is for the subsets assigned to each HLR. For other subsets or individual subscriber records, the designated primary and secondary HLRs may be different. Additionally, when the table says that HLR-2 sends a QUALDIR message to the MSC, it should be recognized that the message is sent to the MSC where the subscriber is active, for those subscriber records for which HLR-2 is the designated backup HLR.

CASE	HLR-1	LINK-1	LINK-2	ACTION
1	UP	DOWN	DOWN	HLR-2 detects no heartbeat, changes to primary and sends QUALDIR message to MSC. HLR-2 records all changes made in subscriber records until links are restored. When links are restored, HLR-2 updates HLR-1 on all the changes made while the links were down, and sends QUALDIR message to MSC designating HLR-1 as primary.
2	UP	UP	DOWN	HLR-1 detects that Link-2 is down and stops heartbeat to HLR-2. HLR-2 changes to primary and sends QUALDIR message to MSC. When Link-2 is restored, HLR-1 sends heartbeat to HLR-2. HLR-2 sends changes made in subscriber records to HLR-1 over Link-1, and sends QUALDIR message to MSC designating HLR-1 as primary.
3	UP	DOWN	UP	HLR-2 detects no heartbeat, changes to primary and sends QUALDIR message to MSC. HLR-2 records all changes made in subscriber records until Link-1 is restored. When Link-1 is restored, HLR-2 updates HLR-1 on all the changes made while Link-1 was down, and sends QUALDIR message to MSC designating HLR-1 as primary.
4	UP	UP	UP	No action required.
5	DOWN	DOWN	DOWN	HLR-2 detects no heartbeat, changes to primary and sends QUALDIR message to MSC. HLR-2 records all changes made in subscriber records until links and HLR-1 are restored. When all are restored, HLR-2 updates HLR-1 on all the changes made while the links and HLR-1 were down. HLR-2 sends QUALDIR message to MSC designating HLR-1 as primary.

CASE	HLR-1	LINK-1	LINK-2	ACTION
6	DOWN	UP	DOWN	HLR-2 detects no heartbeat, changes to primary and sends QUALDIR message to MSC. HLR-2 records all changes made in subscriber records until HLR-1 is restored. If Link-2 is still down, HLR-2 remains as primary until Link-2 is restored, and HLR-1 resumes the heartbeat. HLR-2 then sends QUALDIR message to MSC designating HLR-1 as primary.
7	DOWN	DOWN	UP	HLR-2 detects no heartbeat, changes to primary and sends QUALDIR message to MSC. HLR-2 records all changes made in subscriber records until HLR-1 and Link-1 are restored. When HLR-1 and Link-1 are restored, HLR-2 updates HLR-1 on all the changes made while HLR-1 and Link-1 were down. HLR-2 then sends QUALDIR message to MSC designating HLR-1 as primary.
8	DOWN	UP	UP	HLR-2 detects no heartbeat, changes to primary and sends QUALDIR message to MSC. HLR-2 records all changes made in subscriber records until HLR-1 is restored. When HLR-1 is restored, HLR-2 updates HLR-1 on all the changes made while HLR-1 was down. HLR-2 then sends QUALDIR message to MSC designating HLR-1 as primary.

Table 1

Although the present invention has been described in terms of HLRs in a radio telecommunications network, it should also be understood that the method described is also applicable to provide redundancy of memory devices in any data processing system which utilizes a plurality of memory devices.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description. While the system and method shown and described has been characterized as being preferred, it will be readily apparent that various changes and modifications could be made therein without departing from the

scope of the invention as defined in the following claims.

WHAT IS CLAIMED IS:

1. In a radio telecommunications network, a method of providing dynamic redundancy of home location registers (HLRs) for a plurality of subscribers, said network having a plurality of HLRs, each of which has excess memory capacity for storing subscriber records, said method comprising the steps of:

dividing the subscriber records in each HLR into a plurality of subsets; and

assigning, as a secondary HLR for each subset of subscriber records, a different one of the plurality of HLRs in the network.

2. In a radio telecommunications network, a method of providing dynamic redundancy of home location registers (HLRs) for a plurality of subscribers, said network having a plurality of HLRs, each of which has excess memory capacity for storing subscriber records, said method comprising the steps of:

designating one of the HLRs as a primary HLR and each of the other HLRs in the plurality of HLRs as a secondary HLR;

dividing a set of subscriber records in the primary HLR into a plurality of subsets; and

assigning, as a backup for each of the subsets of subscriber records, a different one of the plurality of secondary HLRs.

3. The method of providing dynamic redundancy of HLRs of claim 2 wherein said step of assigning, as a backup for each of the subsets of subscriber records, a different one of the plurality of secondary HLRs includes the steps of:

determining the amount of excess memory capacity in each of the plurality of secondary HLRs;

determining the size of each subset of subscriber records; and

assigning, as a backup for each of the subsets, a secondary HLR with sufficient excess memory capacity to store the assigned subset of subscriber records.

4. The method of providing dynamic redundancy of HLRs of claim 2 further comprising periodically sending a heartbeat signal from the primary HLR to

each secondary HLR whenever the primary HLR is operational.

5. The method of providing dynamic redundancy of HLRs of claim 4 further comprising the steps of:

determining whether the heartbeat signal is received in each secondary HLR; and

sending to the network, a first directive message from each secondary HLR in which it is determined that the heartbeat signal is not received, said first directive message directing the network to utilize the secondary HLR sending the message as the new primary HLR for active subscriber records in the subset of subscriber records assigned to the sending secondary HLR.

6. The method of providing dynamic redundancy of HLRs of claim 5 wherein the step of sending a first directive message to the network includes sending the first directive message to a mobile switching center (MSC) in which the subscriber is operating.

7. The method of providing dynamic redundancy of HLRs of claim 5 further comprising the steps of:

recording all changes made to subscriber records in each secondary HLR after sending the first directive message;

determining whether the heartbeat signal is again received in each secondary HLR; and

sending all the recorded changes made to subscriber records in each secondary HLR to the primary HLR, upon determining that the heartbeat signal is again received.

8. The method of providing dynamic redundancy of HLRs of claim 7 further comprising sending a second directive message from each secondary HLR to the network directing the network to once again utilize the primary HLR as the new primary HLR, upon determining that the heartbeat signal is again received.

9. The method of providing dynamic redundancy of HLRs of claim 4 further comprising periodically sending the heartbeat signal from each secondary HLR to the primary HLR whenever each secondary HLR is operational.

10. The method of providing dynamic redundancy of HLRs of claim 9 further comprising the steps of:

determining whether the heartbeat signal is received in the primary HLR from a particular one of the secondary HLRs;

recording in the primary HLR, all changes made to subscriber records which are backed up in the particular secondary HLR, upon determining that the heartbeat signal is not received in the primary HLR;

determining whether the heartbeat signal is again received in the primary HLR from the particular secondary HLR; and

sending all the recorded changes made to subscriber records in the primary HLR to the particular secondary HLR, upon determining that the heartbeat signal is again received.

11. The method of providing dynamic redundancy of HLRs of claim 10 further comprising the steps of:

stopping the sending of the heartbeat signal from the primary HLR to the particular secondary HLR, upon determining that the heartbeat signal is not received in the primary HLR; and

resuming the sending of the heartbeat signal from the primary HLR to the particular secondary HLR, upon determining that the heartbeat signal is again received.

12. A system for providing dynamic redundancy of home location registers (HLRs) for a plurality of subscribers in a radio telecommunications network, said system comprising:

a primary HLR that stores a set of subscriber records, said subscriber records being divided into a plurality of subsets of known size;

a plurality of secondary HLRs, each of which has excess memory capacity for

storing subscriber records;

means for determining the amount of excess memory capacity in each of the plurality of secondary HLRs; and

means for assigning, as a backup for each of the subsets of subscriber records, a different one of the plurality of secondary HLRs with sufficient excess memory capacity to store the assigned subset of subscriber records.

13. In a radio telecommunications network, a method of providing dynamic redundancy of home location registers (HLRs) for a plurality of subscribers, said method comprising the steps of:

assigning a primary HLR for each subscriber;

assigning a secondary HLR for each subscriber; and

identifying to the network, the assigned primary HLR and the assigned secondary HLR for each subscriber.

14. The method of providing dynamic redundancy of HLRs of claim 13 wherein the step of identifying to the network, the assigned primary HLR and the assigned secondary HLR for each subscriber includes creating new categories in each subscriber's profile to record the subscriber's primary and secondary HLRs.

15. The method of providing dynamic redundancy of HLRs of claim 13 further comprising the steps of:

providing a signaling connection between the assigned primary HLR for each subscriber and the assigned secondary HLR for each subscriber;

periodically sending a heartbeat signal from the assigned primary HLR to the assigned secondary HLR whenever the primary HLR is operational;

determining whether the heartbeat signal is received in the assigned secondary HLR;

determining whether the assigned subscriber is active; and

sending to the network, a first directive message from the assigned secondary HLR when it is determined that the heartbeat signal is not received and the assigned

subscriber is active, said first directive message directing the network to utilize the assigned secondary HLR as the new primary HLR for the assigned subscriber.

16. The method of providing dynamic redundancy of HLRs of claim 15 further comprising the steps of:

recording all changes made to the subscriber's record in the assigned secondary HLR after sending the first directive message;

determining whether the heartbeat signal is again received in the assigned secondary HLR; and

sending all the recorded changes made to the subscriber's record in the assigned secondary HLR to the assigned primary HLR, upon determining that the heartbeat signal is again received.

17. The method of providing dynamic redundancy of HLRs of claim 16 further comprising sending a second directive message from the assigned secondary HLR to the network directing the network to once again utilize the assigned primary HLR as the new primary HLR, upon determining that the heartbeat signal is again received.

18. The method of providing dynamic redundancy of HLRs of claim 15 further comprising the steps of:

periodically sending the heartbeat signal from the assigned secondary HLR to the assigned primary HLR whenever the secondary HLR is operational;

determining whether the heartbeat signal is received in the assigned primary HLR;

recording in the assigned primary HLR, all changes made to subscriber records which are backed up in the assigned secondary HLR, upon determining that the heartbeat signal is not received in the assigned primary HLR;

determining whether the heartbeat signal is again received in the assigned primary HLR from the assigned secondary HLR; and

sending all the recorded changes made to subscriber records in the assigned

primary HLR to the assigned secondary HLR, upon determining that the heartbeat signal is again received.

19. The method of providing dynamic redundancy of HLRs of claim 18 further comprising the steps of:

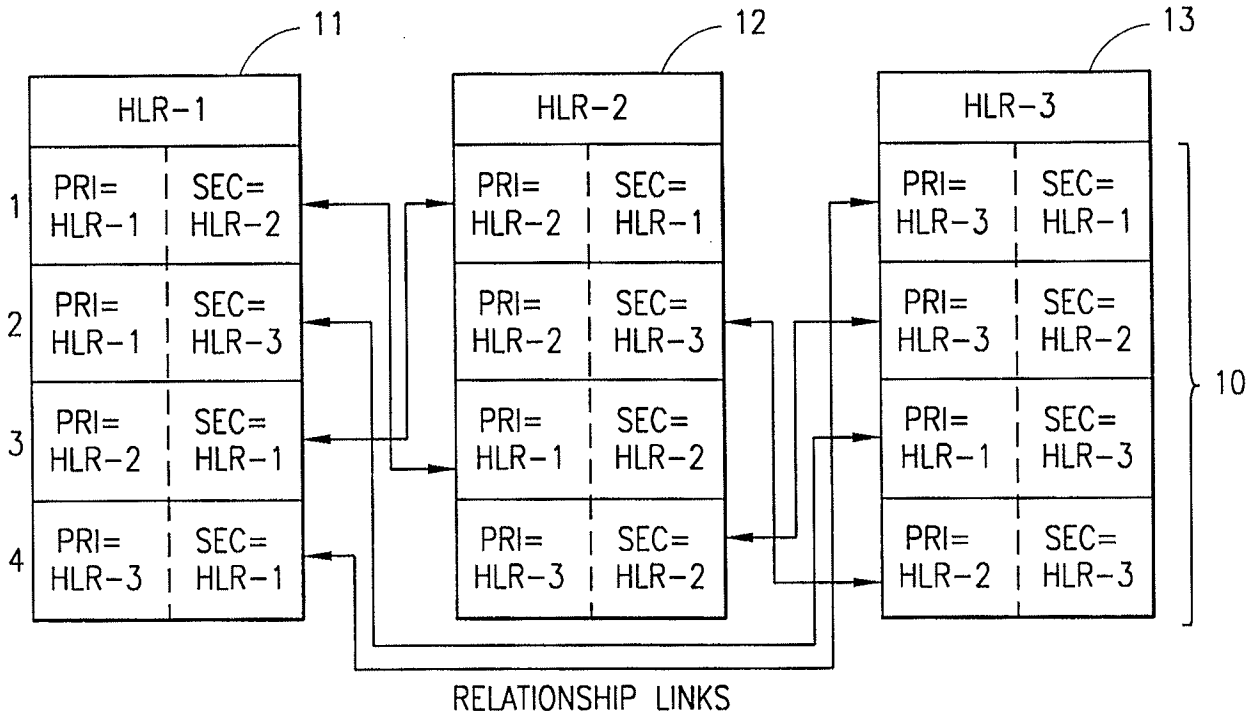
stopping the sending of the heartbeat signal from the assigned primary HLR to the assigned secondary HLR, upon determining that the heartbeat signal is not received in the assigned primary HLR; and

resuming the sending of the heartbeat signal from the assigned primary HLR to the assigned secondary HLR, upon determining that the heartbeat signal is again received.

20. A method in a data processing system of providing dynamic redundancy of memory devices, said data processing system having a plurality of memory devices, each of which has excess memory capacity for storing data, said method comprising the steps of:

dividing the data in each memory device into a plurality of subsets; and

assigning, as a secondary memory device for each subset of data, a different one of the plurality of memory devices in the data processing system.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PRI= HLR-2
SEC= HLR-1
PRI= HLR-2
SEC= HLR-3
PRI= HLR-1
SEC= HLR-2
PRI= HLR-3
SEC= HLR-2
PRI= HLR-3
SEC= HLR-1
PRI= HLR-3
SEC= HLR-2
PRI= HLR-1
SEC= HLR-3
PRI= HLR-2
SEC= HLR-3
10
RELATIONSHIP LINKS

FIG. 1

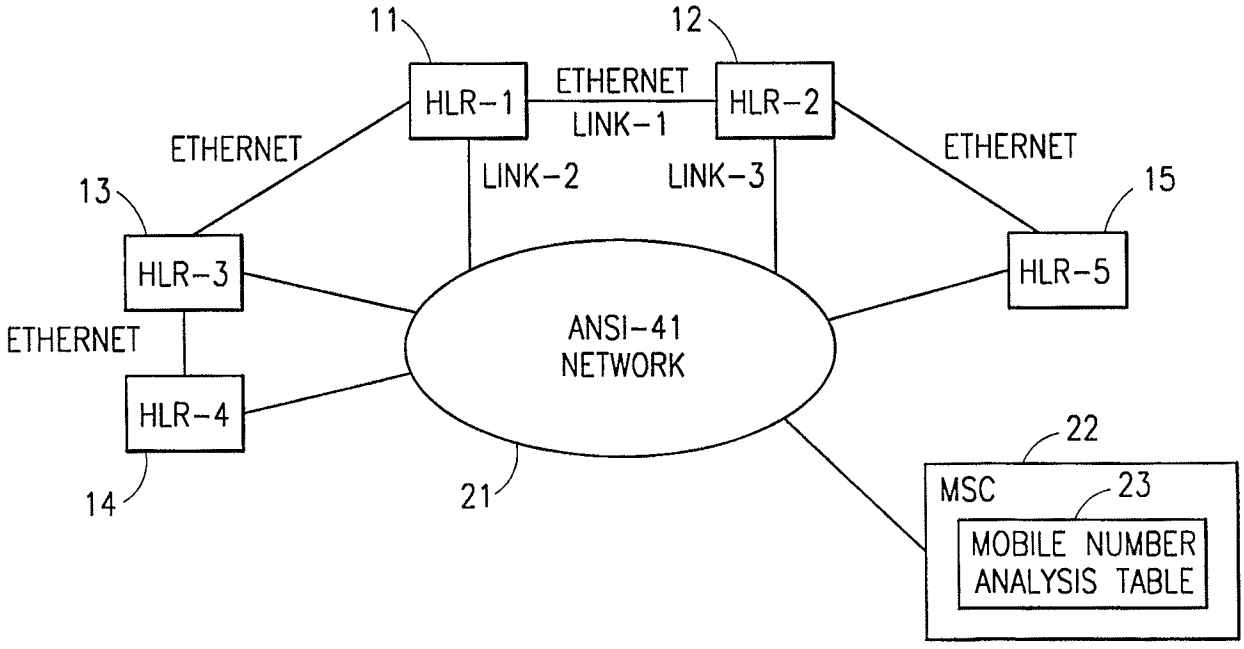
11
12
HLR-1
ETHERNET
LINK-1
HLR-2
ETHERNET
LINK-2
LINK-3
ETHERNET
13
15
HLR-3
HLR-5
ETHERNET
ANSI-41
NETWORK
HLR-4
14
21
22
MSC
23
MOBILE NUMBER
ANALYSIS TABLE

FIG. 2